Fermilab
PPD/MD/Engineering Analysis Group

**The Summary of the Result for a Model Including
Both Vertical and Horizontal Extrusion (Mini 3-D model)**
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A 3-D model with both vertical and horizontal has been created to analyze the real structure of the TASD as shown in Fig 1. Since the structure is made of many small cells which has an identical geometry, a small portion of the structure is needed for the purpose of the modeling as shown in Fig 2. A symmetry boundary condition is used for the top & bottom, left & right, front & back side of the model. It uses the solid element from ANSYS. Two sets of the calculation are done as following:

For tside=3mm & trib=2mm

1) A vertical and horizontal extrusion is fully glued:
a) The maximum deflection along the beam direction is about 1 mils as shown in Fig 2.
b) The stress is about 300 psi as shown Fig 3. It is due to a total 6 mm thickness of the sidewall, resulting from gluing vertical and horizontal together.
c) The shear stress is developed in the mid plane where the glue layer is. The maximum shear stress is about 75 psi as shown in Fig 4. The simple analytic solution for a build-up beam indicates that maximum shear stress should be less 100 psi.

2) The case without any glue between the vertical and horizontal extrusion.
A contact (gap) element is used between the vertical and horizontal extrusion to simulate the actual contact behavior. Two sidewalls could contact and slide each other. They could also open up as shown in Fig 5 and Fig 6.
a) The maximum deflection along beam direction is about 2.4 mils.
b) The maximum stress is 650 psi.
It indicates that the structure is still holding well even the glue breaks by some reasons as long as a bookend is in place.

3) The vertical extrusion standing alone (without the horizontal extrusion).
a) The maximum deflection is about 7 mils __ Fig 7.
b) The maximum stress is about 1,500 psi __ Fig 8.
This is the case used to design the individual extrusion so far. It is the worst case, indeed.

For tside=2mm & trib=1mm

1) A fully glued case shown in Fig 9, 10, and 11
a) The maximum deflection along the beam direction is about 2.4 mils as shown in Fig 9
b) The stress is less 700 psi as shown Fig 10(we have 4 mm wall total with gluing them together).

c) The shear stress is developed in the mid plane where the glue layer is. The max shear stress is about 100 psi as shown in Fig 11.

2)The case without any glue between the vertical and horizontal extrusion.
a) The maximum deflection along beam direction is about 7mil __ Fig 12.
b) The maximum stress is 1450 psi. __ Fig13.

3) The vertical extrusion stands alone (without the horizontal extrusion)
a) The maximum deflection is about 20 mils __ Fig 14.
b) The maximum stress is about 3,300 psi __ Fig 15.
This is the case used to design the individual extrusion so far. It is the worst case, indeed.

Table 1 The Summary of the Calculation Result
For t(side wall)=3 mm, t(rib)=2 mm

	Vertical and Horizontal extrusions Fully Glued	No Glue	Standing alone	
Deflection (mils) (Beam direction)	1	2.4	7	
Max Stress (psi)	307	632	1,500	Limit working[1] stress < 1,800 psi
Max shear stress in mid plane (psi	72	N/A	N/A	

Table 2 The Result For the Case of t(side wall)=2 mm, t(rib)=1 mm

	Vertical and Horizontal extrusions Fully Glued	No Glue	Standing alone	
Deflection (mils) (Beam direction)	2.4	6.6	20	
Max Stress (psi)	663	1,400	3,300	Limit working[2] stress < 1,800 psi
Max shear stress in mid plane (psi)	111	N/A	N/A	

Note:
   1) For the vertical cell at very end of extrusion, the stress still equals 1,950 psi for tside=3 mm and 3,800 psi for tside=2 mm, respectively (The span is longer than interior cell and there is no horizontal extrusion).

2) The standing alone case is the worst case, indeed. If the design based on the individual extrusion(which it is so far) works, the actual operating case will be better, at least by factor of two from above.
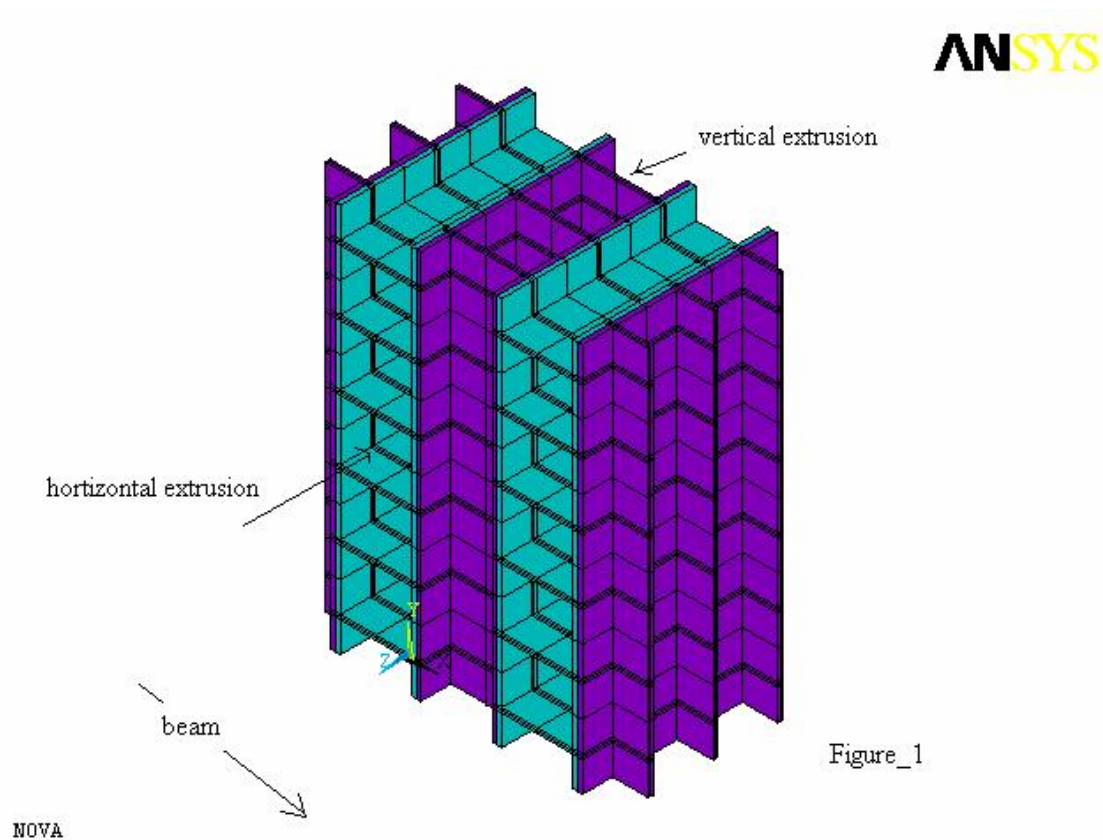

vertical extrusion

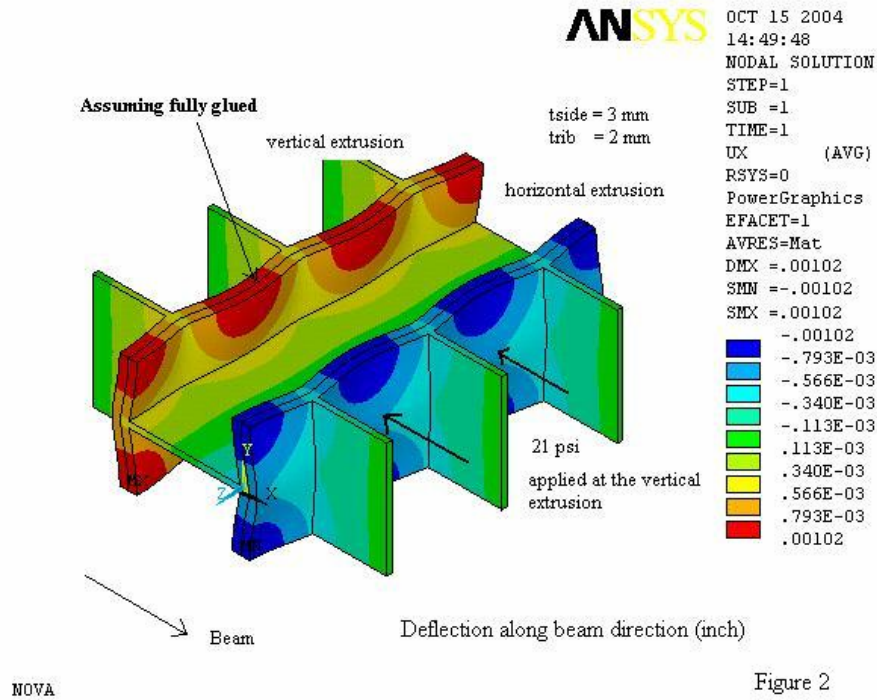hortizontal extrusion

beam

NOVA

Figure_1

Fig 1 The Nova PVC' s structure

Assuming fully glued

vertical extrusion

horizontal extrusion

tside = 3 mm
trib = 2 mm

OCT 15 2004
14:49:48
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
UX   (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.00102
SMN =-.00102
SMX =.00102

21 psi

applied at the vertical
extrusion

-.00102
-.793E-03
-.566E-03
-.340E-03
-.113E-03
.113E-03
.340E-03
.566E-03
.793E-03
.00102

Beam

Deflection along beam direction (inch)

Figure 2

NOVA

Fig 2 The deflection along the beam direction

Assuming fully glued

tside = 3 mm
trib = 2 mm

OCT 15 2004
14:50:58
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SINT   (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.00102
SMN =9.78
SMX =307.374

9.78
42.846
75.912
108.978
142.044
175.11
208.176
241.242
274.308
307.374

psi

Stress for two side walls fully glued (21 psi applied at the vertical extrusion only)

Figure 3
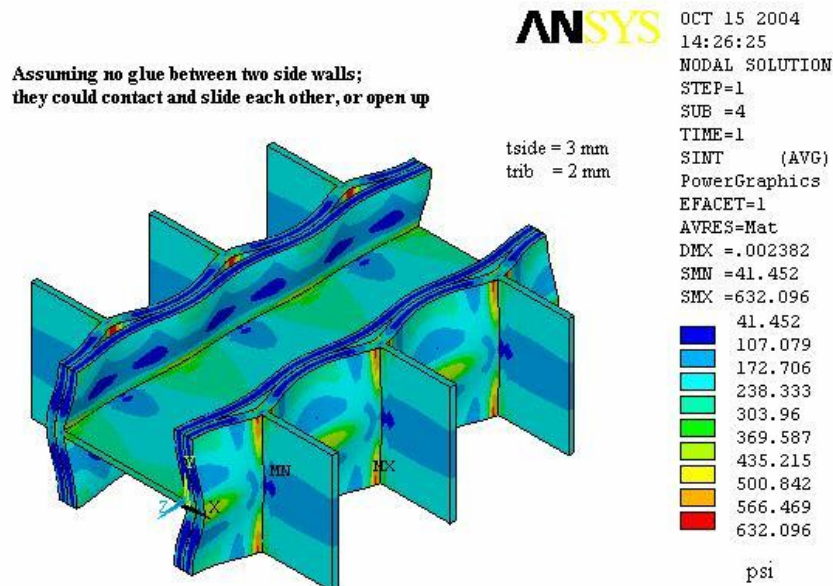
NOVA

Fig 3 The stress for a fully glued case

4

Fig 4 The shear stress for a fully glued case
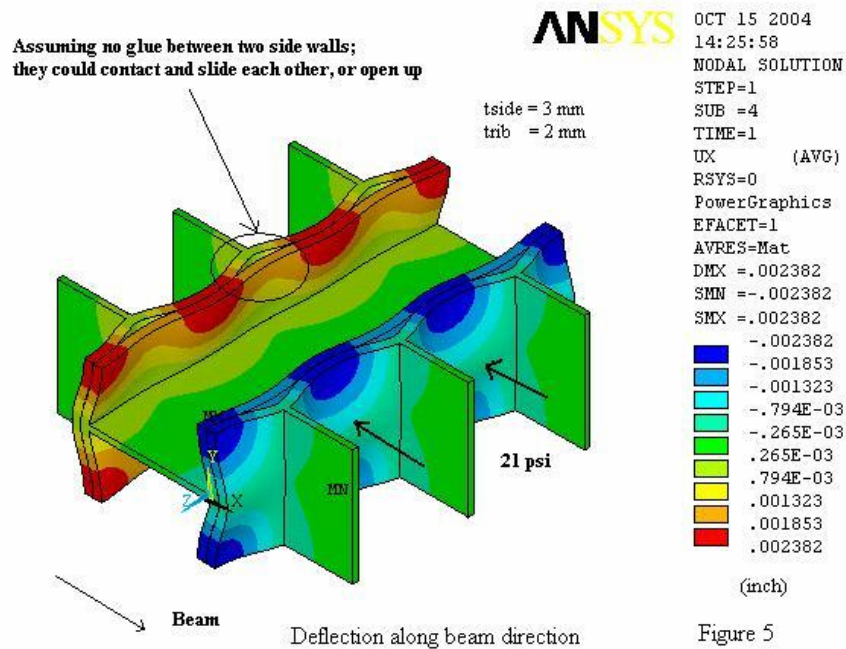
Fig 5 The deflection along the beam direction for no glue case

Stress for the case of the two side walls without any glue

Assuming no glue between two side walls;
they could contact and slide each other, or open up

tside = 3 mm
trib = 2 mm

OCT 15 2004
14:26:25
NODAL SOLUTION
STEP=1
SUB =4
TIME=1
SINT   (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.002382
SMN =41.452
SMX =632.096

41.452
107.079
172.706
238.333
303.96
369.587
435.215
500.842
566.469
632.096

psi

Figure 6

NOVA

Fig 6 Stress for a "no glue" case

Vertical extrusion only (no horizontal extrusion)

tside = 3 mm
trib = 2 mm

3.8 cm

21 psi applied

beam

Deflection along beam direction (inch)
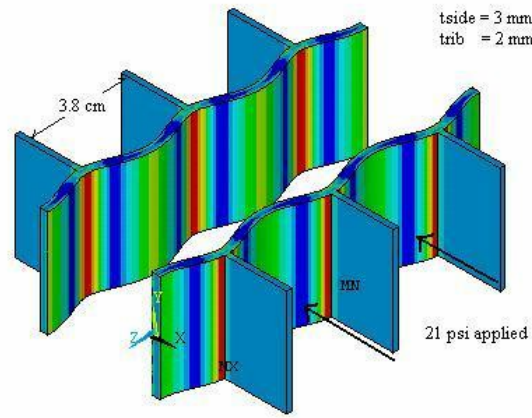
ANSYS 7.1
OCT 15 2004
15:08:02
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
UX   (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.007017
SMN =-.007017
SMX =.007017

-.007017
-.005458
-.003898
-.002339
-.780E-03
.780E-03
.002339
.003898
.005458
.007017

Figure 7

NOVA

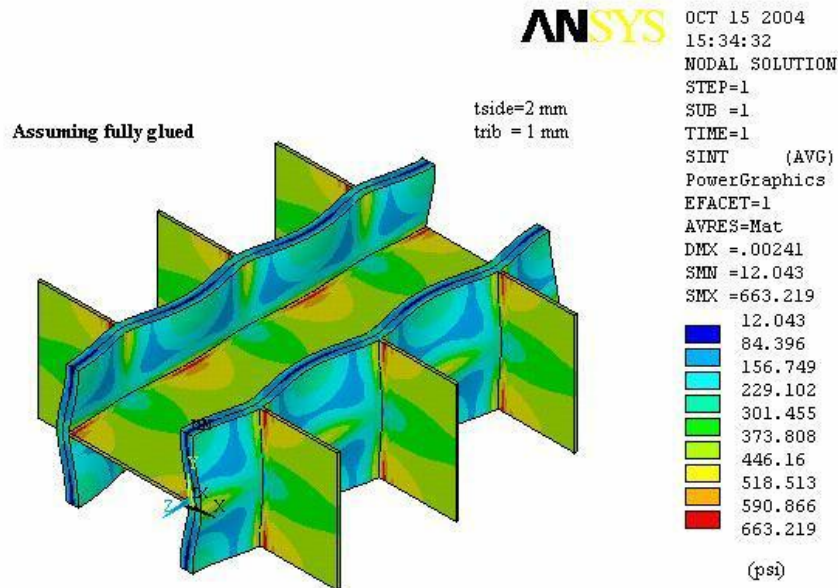**Fig 7 The deflection along the beam direction with a vertical extrusion only**

6

Figure 8 The stress for the case with a vertical extrusion only
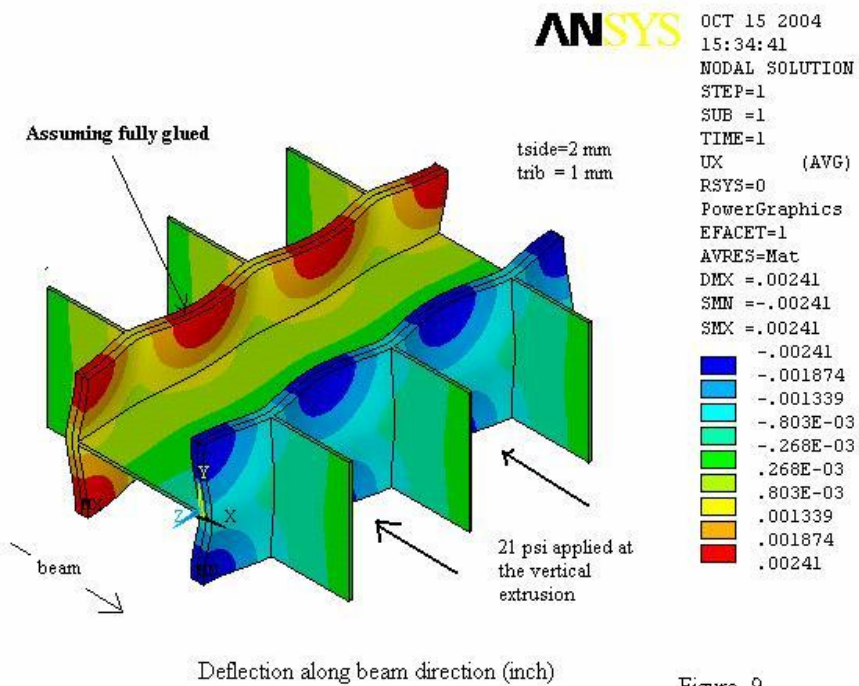
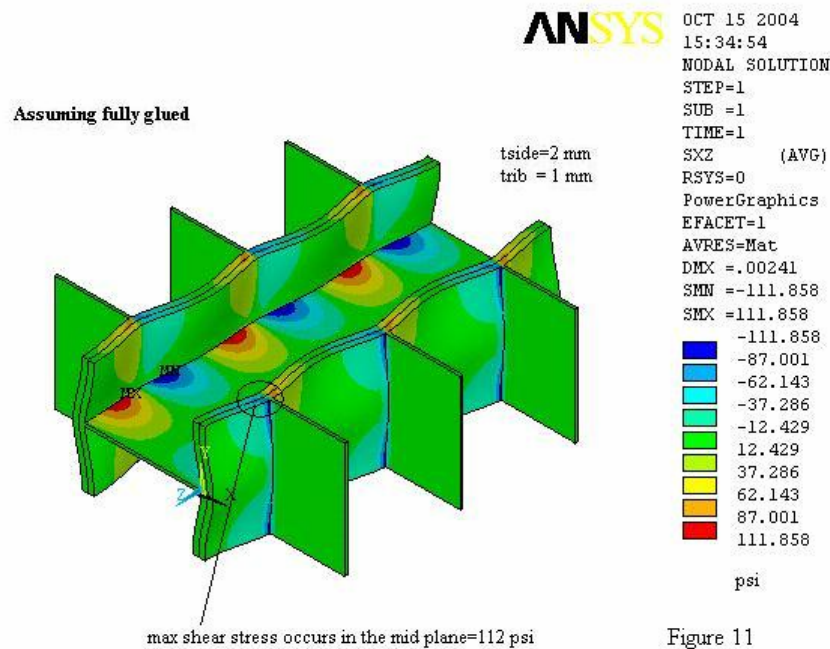**Fig 9 The deflection along the beam direction**

7

Fig 10 The stress for a fully glued case

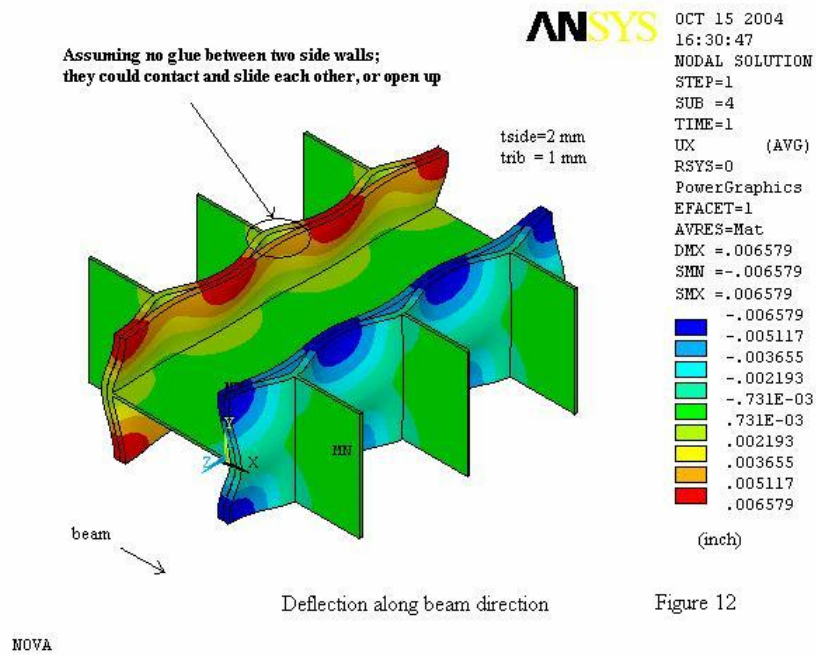**Fig 11 The shear stress for a fully glued case**

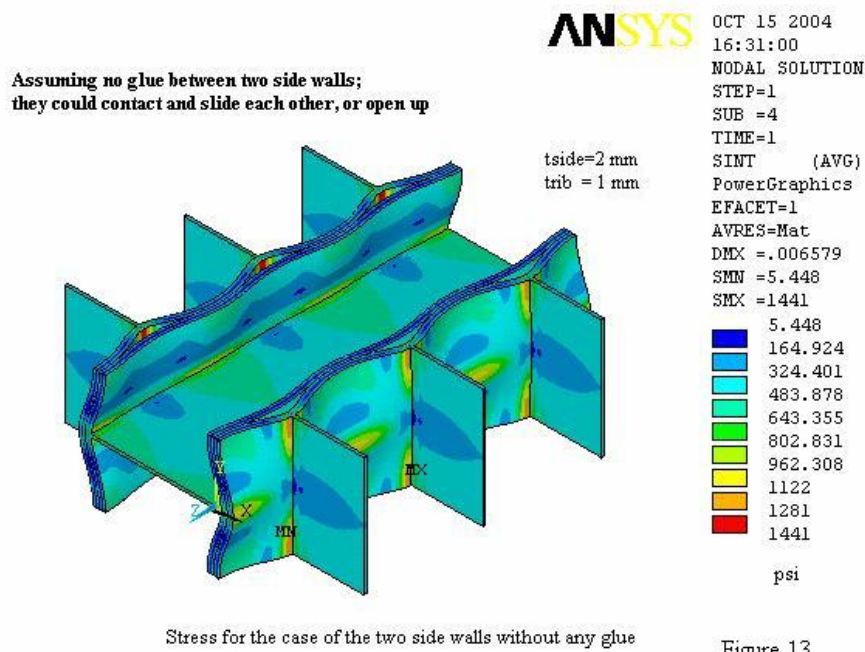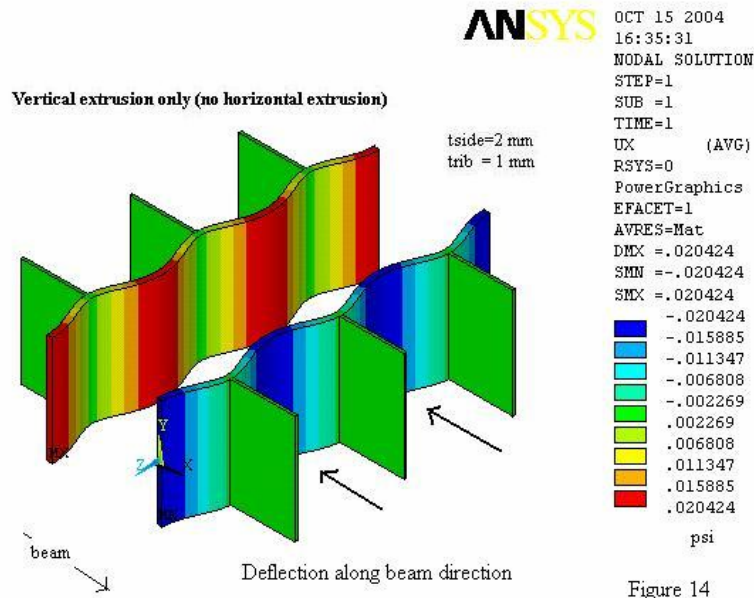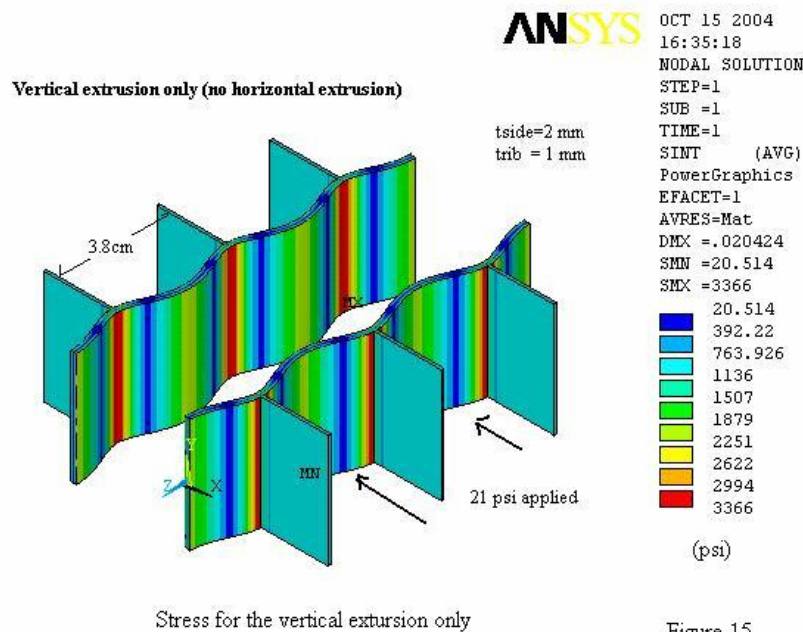**Fig 12 The deflection along the beam direction for the case without any glue**

Fig 13 The stress for the case without any glue

Fig 14 The deflection along the beam direction for the case with a vertical extrusion only

Fig 15 The stress for the case with a vertical extrusion only